
EE566 Solid State Devices

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Dept of Electrical Engineering

University of Notre Dame

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Assignment 1

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Due: 01/28/2008

Reading: Chapter 1 of the Textbook (Muller/Kamins/Chan: MKC) & the Appendix of Chapter 1 on “Electric Fields... Gauss’s Law”. For material constants & parameters, Table 1.3 page 52 of MKC should work. For materials not listed in this table, go to - <http://www.ioffe.rssi.ru/SVA/NSM/>.

Problem 1*

Explain, with the help of relevant sketches, the difference between a direct (D) and indirect (I) bandgap semiconductor. Compare, with physical reasoning, the following properties for D & I semiconductors:

- Valley degeneracy & Conduction band Density of States (DOS)
- Electron effective masses
- Electron mobilities
- Optical absorption coefficients (solve Problem 1.14 from MKC as a part of your answer)
- Minority carrier lifetimes

Problem 2

Magnesium is a relatively “deep acceptor” in the wide bandgap semiconductor GaN. The acceptor ionization energy is $E_A \sim 160\text{meV}$. Consider a GaN sample doped with $N_A = 10^{19}/\text{cm}^3$ of Magnesium atoms. In the process of doping this sample with Magnesium, unintentional donors of density $N_D = 10^{16}/\text{cm}^3$ ($E_D = 10\text{meV}$) also incorporate into the semiconductor.

- Find the Fermi level in the semiconductor at $T = 300\text{K}$.
- For $T = 300\text{K}$, Plot n , p , N_A^- , N_D^+ , $n + N_A^-$, and $p + N_D^+$ as a function of the Fermi level E_F . Remember the Fermi level can be within the gap or in the conduction or valence bands. Therefore choose values of E_F from below E_V to above E_C . Indicate in the plot where the real Fermi level at 300K is. Explain.
- Indicate the donor and acceptor ionization energies in your figure.
- What are the densities and types of mobile carriers in the sample at 300K? Is the sample n- or p-type?

Problem 3

Solve Problem 1.12 from MKC.

Problem 4

Solve Problem 1.15 from MKC.

Problem 5

Solve Problem 1.16 from MKC.

Problem 6

Solve Problem A1.4 (not 1.4!) from MKC. (Reading the Appendix of Chapter 1 will help!)

In general, I suggest you read the chapter-end problems of MKC (chp 1 + appendix) and make sure that you are comfortable with them (i.e., you can answer them if you have to!).

* Remember to use proper units and label every figure/plot. Turn in your answers worked out neatly. Please attach this question sheet to your solution when you turn it in.